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TIME PRESSURE AND INSTINCTIVE RESPONSES TO DRIVING DILEMMAS

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Abstract

The rapid advancement of autonomous vehicles (AVs) raises concerns about how machines make moral decisions. When a collision is unavoidable, the nature and way AVs crash become a critical ethical issue because AV algorithms select a specific course of action from a range of options. The Asilomar AI Principles advocate that machine ethics should align with human values. With no consensus on ethical standards, studying how humans make decisions in moral dilemmas aims to bridge the gap between human morality and moral algorithms' design. This line of research serves as a crucial reference for the development of ethical algorithms for autonomous vehicles. Previous research demonstrates a discrepancy in whether participants always make utilitarian choices (u-choices) in driving. This study explored how time pressure influenced decision-making, particularly utilitarian decision-making in driving dilemmas. U-choices maximize lives saved and minimize harm. Participants were given 2 s, 3 s, or 5 s to decide how to respond to a driving dilemma in which one pedestrian (ped) was on one side and five peds were on the other side of the road. Thirty-one undergraduates participated in the study and responded to driving moral dilemmas at three different levels of time pressure, and drivers' behavior was measured and recorded in a STISIM driving simulator. The findings highlight the prevalent trend of individuals generally favoring u-choices, except during the first scenario. Moreover, decreased time pressure did not significantly increase the percentage of u-choices, but u-choices increased if excluding the first scenario (with 5 s to respond, one ped on the left). Future studies are needed to determine how participants' exposure to moral dilemmas influences decision-making. Additionally, we investigated whether drivers rely on an instinctive response in driving dilemmas. Most participants responded toward the direction that was consistent with u-choices. The findings have potential implications and applications in aligning machine ethics with human values.

Keywords: *Autonomous vehicles, decision making, time pressure, moral dilemmas, driving simulator.*

1. Introduction

Six hundred eighty-four accidents involving autonomous vehicles (AVs) were reported as of January 26, 2024 in California alone (*Autonomous Vehicle Collision Reports*, n.d.). Human errors are claimed to cause most crashes. However, pedestrians and human drivers sharing roads with AVs poses a challenge for AV safety (Schwall et al., 2020; Goodall, 2014). Therefore, collisions will likely persist into the near future (Lin, 2016). If a collision is unavoidable, then how a vehicle crashes and what it crashes into could be lifesaving (Lin, 2016), and an AV's actions becomes an ethical issue with an outcome determined by its algorithm (Goodall, 2014). AV algorithms are still undergoing development, and the limited consensus on which ethical standards AV algorithms should prefer presents a challenge in developing AVs with ethical standards aligning with the Asilomar AI principles' suggestions that machine ethics should align with human values (Morandín-Ahuerma, 2024). Utilitarianism corresponds to choices that minimize harm and maximize the overall good (Lin, 2016). Previous research often suggests that humans favor utilitarian choices (u-choices) in driving moral dilemma scenarios (Gao et al., 2020: 73% u-choices; Pradhan et al., 2019 survey: 68.75% u-choices). However, Samuel et al. (2020) found that only 43% of participants made u-choices, revealing a situation where the majority did not make u-choices with 2 s time pressure. Likewise, in Pradhan et al.'s (2019) simulator study, only 43.75% made u-choices, which is lower than similar studies (e.g., Gao et al., 2020). Time pressure and response preferences/reflexes potentially influence moral dilemma decision making (Frank et al., 2019; Samuel et al., 2020; Suter & Hertwig, 2011; Pradhan et al., 2019). This study investigates how these two variables may contribute to the controversial results of previous studies (e.g., Gao et al., 2020; Samuel et al., 2020; Pradhan et al., 2019).

2. Methods

Participants: Thirty-one undergraduate students (mean age = 20.42 years) were recruited from an online system (SONA) who had or were eligible for a driver's license and had not experienced simulator related concerns before (i.e., motion sickness, epilepsy, etc.). Some students were compensated with extra course credit. The university's Institutional Review Board (IRB) approved the study.

Materials: This study used the STISIM-Model 100 driving simulator along with a Logitech steering wheel/brake/gas pedal, and a Dell 17-inch monitor. Simulated driving was programmed on a two-lane undivided suburban road. Participants completed a practice run and an experimental run. The settings were similar between the two runs, except in the experimental run, the vehicle was set in cruise mode (speed around 35 mph). There are two types of scenarios (six pedestrian-type scenarios and six vehicle-type scenarios) in the experimental run. Only pedestrian-type scenarios' data was reported here. In the pedestrian scenarios, participants responded to two dilemma types: one with a pedestrian on the left and five pedestrians on the right side of the road (1PedLeft) and one where the two pedestrian groups switched their locations (1PedRight). In each scenario, pedestrians on either side of the road started walking across the street at 2 s, 3 s, or 5 s Time to Collision (TTC) from the participant's car. Demographic and impulsiveness data were collected in two Qualtrics surveys. After signing a consent form, participants completed a practice simulation, then randomly selected/completed one of the two surveys, the experimental run, and the other survey. Scenarios were presented in this order: 1PedLeft, 5 s TTC → 1PedRight, 3 s TTC → 1PedRight, 5 s TTC → 1PedRight, 2 s TTC → 1PedLeft, 3 s TTC → 1PedLeft, 2 s TTC.

Data Organization: For each scenario, data recording started 2 s before the pedestrians started walking across the road. Participants' response types were categorized in terms of utilitarian response-type (u/non-u) and turning direction (left, right, or straight) based on the simulator's raw data. Participants' reaction time (RT), total proportion of u-choices, the proportion of u-choices and RT for each TTC condition, and the number of left/right choices for each scenario were also derived from the raw data. If a participants' steering wheel turned less than 25 degrees in a scenario, their response was classified as moving straight. If the steering wheel turned over 25 degrees, the response was categorized as left or right. U-choices were defined as responses that did not result in hitting the five pedestrian group.

3. Results

The results showed that the mean percentage of participants that made u-choices was about 77% across all scenarios. There was no main effect of TTC on the percentage of u-choices, p = .272. But the tendency was that percentage increased as TTC increased, except for the scenario with the lowest u-choices (1PedLeft, 5 s TTC), which was also the first scenario in the test run. Another 2 x 3 ANOVA was conducted to test TTC and u-choices (u/non-u choices) on the pedestrians injured, which was another measure for u-choices. Both the main effects for TTC and u/non-u choices were marginally significant, (p = .07 & .08), but the interaction was significant, $F(2, 60) = 5.56$, $p = .006$, $\eta 2 = .16$, indicating that there was no advantage for u-choices for 2 or 3 s TTC, but there was an advantage for u-choices for 5 s TTC (see Table 1).

Table 1. Number and Percentage of Utilitarian Choices at Each Time-to-Collision and Scenario Type.

Time to collision (TTC)	One Pedestrian Left	One Pedestrian Right	Mean	Mean Pedestrians Injured (U/Non U)
2 s	20 (65%)[a]	26 (84%)	75%	1.55/1.16
3 s	22 (71%)	29 (94%)	83%	1.90/.81
5 s	15 (48%)	31 (100%)	74%	.90/1.19
Mean	61%	93%	77%	1.45/1.05

[a] Similar to Samuel et al.'s (2020) condition which obtained 43% u-choices. Coding similarly the percent u-choices in this study was 62%.

The number of responses (left or right) was analyzed with scenario type and response direction as within-subject variables. There was no significant difference in the number of left (M = 1.0) or right responses (M= .69), $F(1, 30) = 3.32$, $p = .079$, but the means suggested participants responded left more often. The main effect of dilemma type was significant, $F(1, 30) = 10.11$, $p = .003$, $\eta 2 = .25$, indicating participants responded significantly more when 1PedLeft than when 1PedRight (Ms = .98 & .71). The interaction was also significant, $F(1, 30) = 27.01$, $p < .001$, $\eta 2 = .47$, demonstrating that when one pedestrian was on the left (*M*s = 1.61 & 0.35), participants were more likely to respond left (u-choice), and when one pedestrian was on the right (*M*s = 1.03 & 0.39), participants were more likely to respond right (u-choice). Results further indicated participants selected u-choices in both pedestrian scenario types.

4. Discussion & conclusion

The current simulator study explored drivers' decision-making during unavoidable collisions with pedestrians, focusing on how time pressure and instinct influenced utilitarian tendencies. While TTC did not influence u-choices significantly, if excluding the lowest u-choice scenario (1PedLeft, 5s TTC), u-choices generally increased and pedestrians injured decreased as time pressure decreased. This result was consistent with the general finding that as time pressure decreased, u-choices increased. Swerving response tendencies did not suggest instinctive responses (left or right) under any scenarios, but swerving responses did support utilitarian tendencies. Although participants were more likely to make swerving responses to scenarios with 1PedLeft than 1PedRight, this difference indicates that ethical issues were incorporated into decision making because making swerving responses was more likely to avoid hitting five pedestrians (leading to u-choices). The significant interaction of response direction and ped location further reinforces support for utilitarian tendencies. Policy makers and AI programmers should consider the general preference for u-choices our results suggest and implement these preferences into their designs/regulations. The closest scenario in our study to Samuel et al.'s (2020) scenario was 1PedLeft, 2 s TTC. Next, we recoded our data similarly to Samuel et al.'s (2020) data (left vs. right). Our percentage of u-choices (62%) was still higher than their percentage (43%), but our first scenario's results (48%: 5 s TTC, 1PedLeft) were comparable to the results of Samuel et al.'s (2020) first and only scenario (43%). The relatively low percentage of u-choices may be due to the fact that participants did not have previous exposure to similar pedestrian scenarios. However, another similar study conducted by Gao et al. (2020) showed a higher percentage of u-choices (73%) for their only scenario in study 1, with a set up similar to Samuel et al. (2020)'s scenario 1 and our 1PedLeft, 2s TTC scenario. Even though all studies had a practice run, in Gao et al.'s (2020) study, participants were told explicitly that brakes may fail, and they did not mention whether participants experienced a similar scenario in their practice run. Differences between practice runs may contribute to the results' differences. Therefore, when conducting research regarding decision-making with driving dilemmas, scenario exposure may influence results and should be controlled in research design.

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